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Pelosi et al.

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[45] **Date of Patent: Mar. 7, 2000**

[54] **DIODE MODULE ASSEMBLY WITH BIFURCATED TERMINALS**

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[73] Assignee: **Lucent Technologies Inc.**, Murray Hill, N.J.

[21] Appl. No.: **09/097,251**

[22] Filed: **Jun. 12, 1998**

[51] **Int. Cl.**[7] **H01L 23/62**; H02H 3/20

[52] **U.S. Cl.** **361/119**; 361/820; 361/824; 257/686; 257/691; 257/692

[58] **Field of Search** 361/118, 119, 361/56, 57, 91, 98, 111, 117, 728, 747, 806, 807, 809, 820, 824, 775; 455/90, 117, 128, 217, 252.1, 347, 348, 349; 257/686, 723, 724, 726, 727, 691, 692, 698

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Primary Examiner—Leo P. Picard
Assistant Examiner—John B. Vigushin

[57] **ABSTRACT**

A telecommunications protection unit includes a voltage unit having an electrically insulating base configured to house a diode module assembly and a voltage limiting cell therein. The voltage limiting cell and diode module assembly are retained within the housing by a bus clip. The housing includes structure for preventing damage to the voltage limiting cell and diode module assembly during placement of the bus clip thereon. The diode module assembly is a one-piece article including a bus bar and several diodes and terminals which can be used by itself or in a voltage unit to provide desired electrical effects and facilitate assembly of an electrical system such as a telecommunications protection unit. The terminals of the diode module are highly flexible to respond to excessive voltage and sneak current events encountered by telecommunications protection equipment, and the bus clip is constructed to provide a plurality of independently yieldable segments to accommodate diode stacks of variable heights and reduce manufacturing costs.

8 Claims, 9 Drawing Sheets

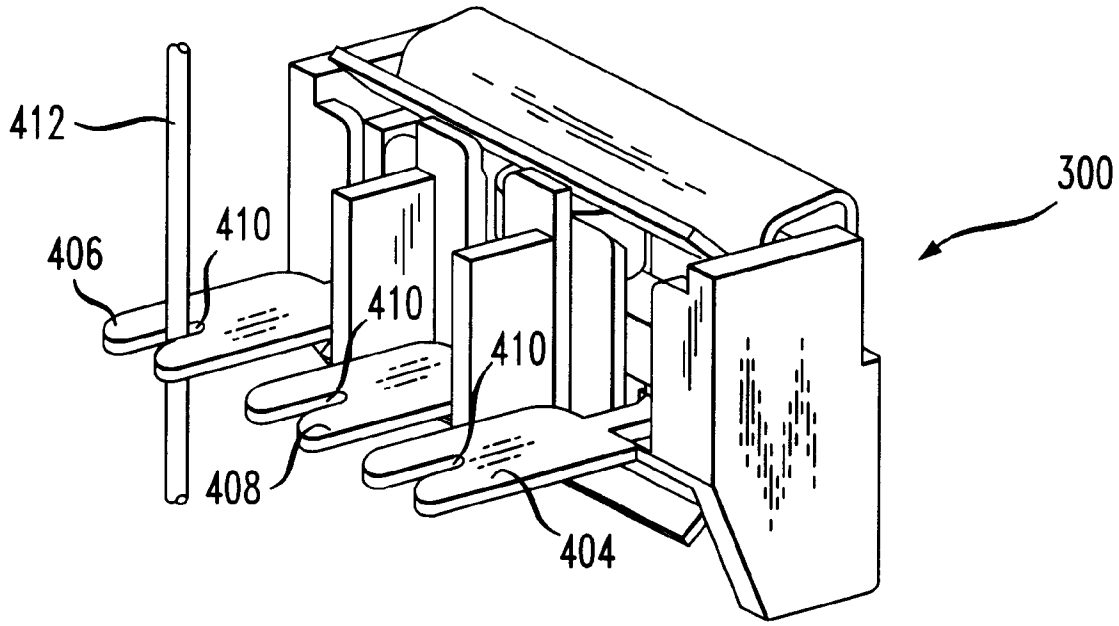


FIG. 1A
PRIOR ART

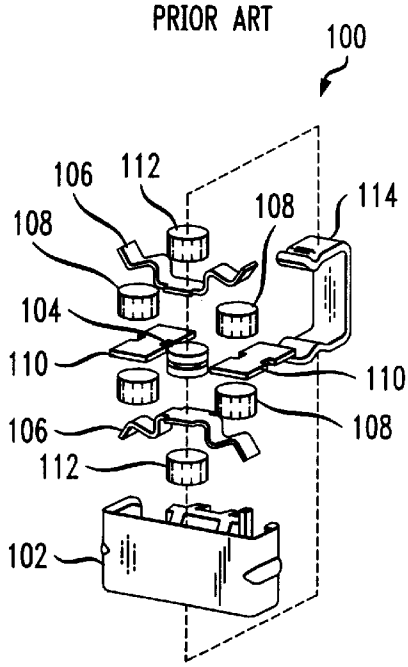


FIG. 1B
PRIOR ART

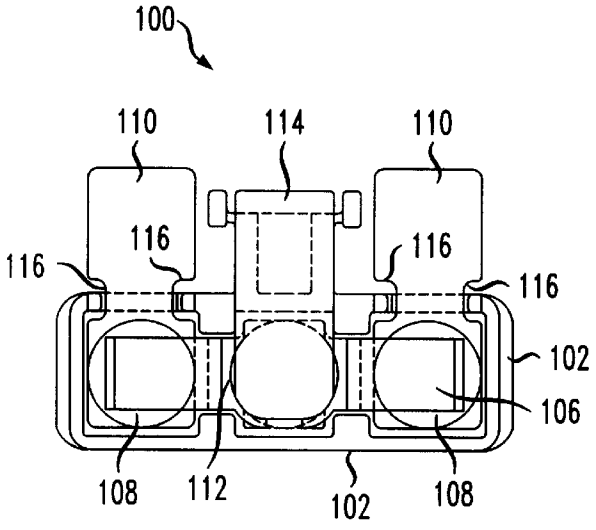


FIG. 1C
PRIOR ART

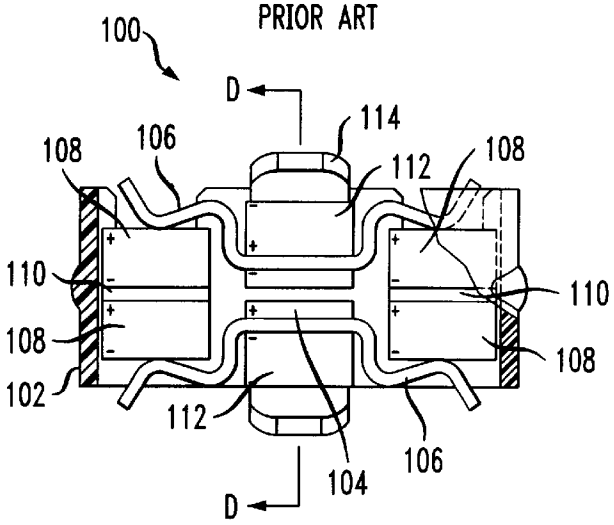


FIG. 1D
PRIOR ART

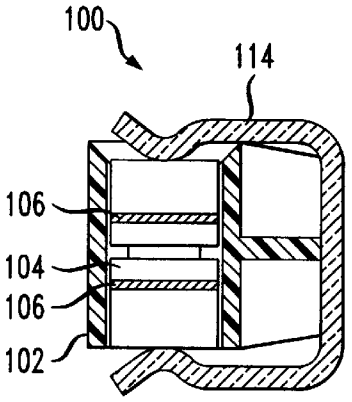


FIG. 2

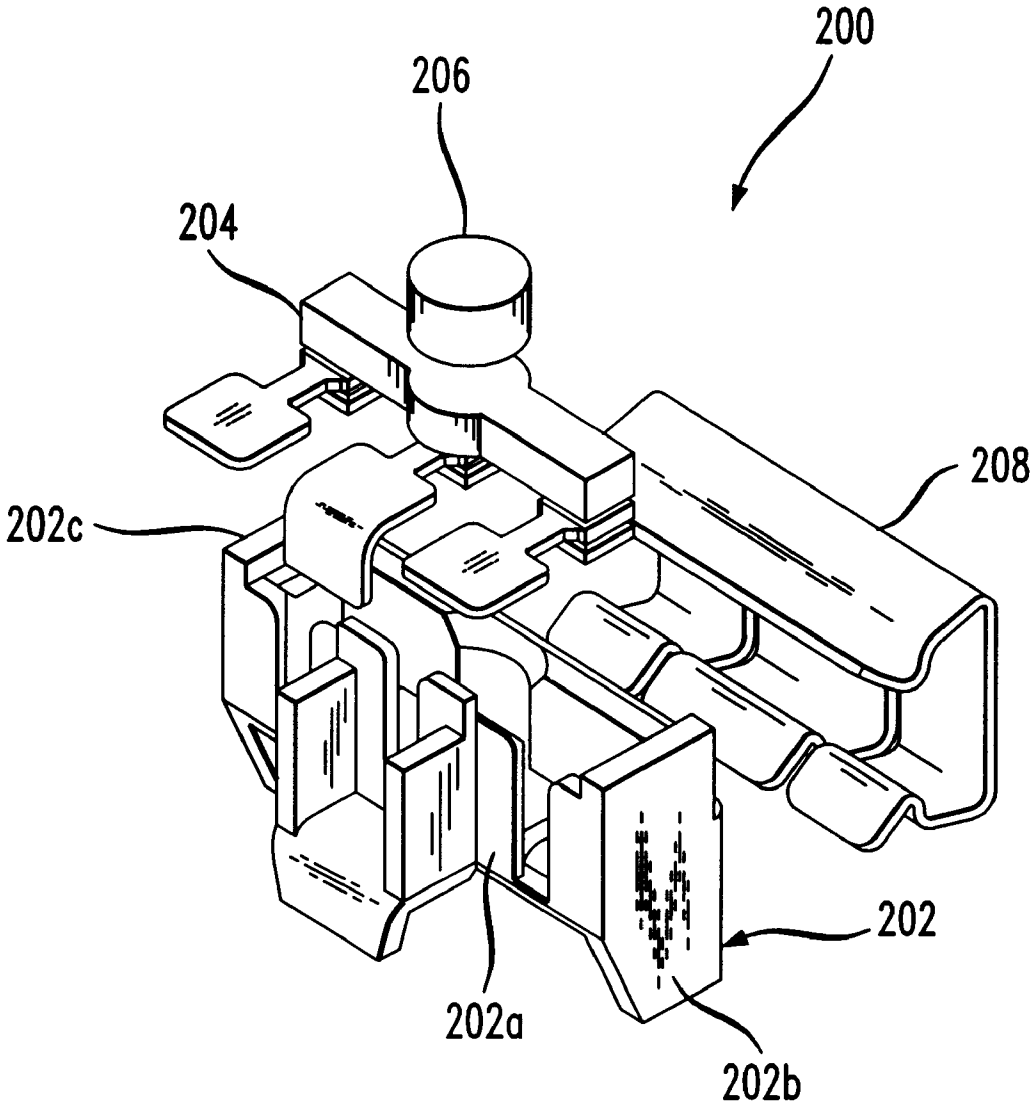


FIG. 3

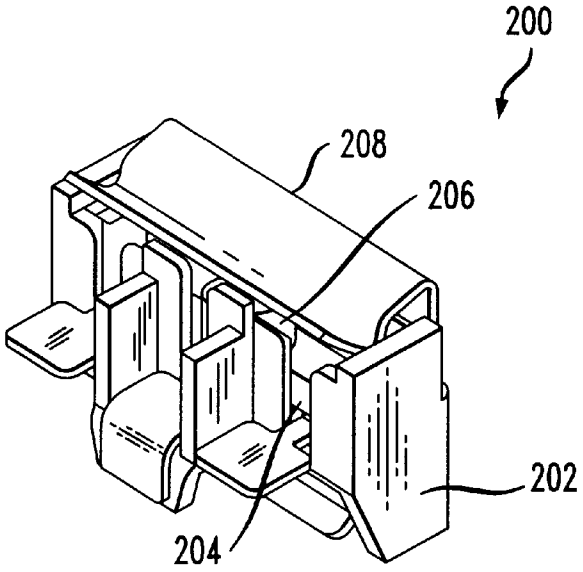


FIG. 4

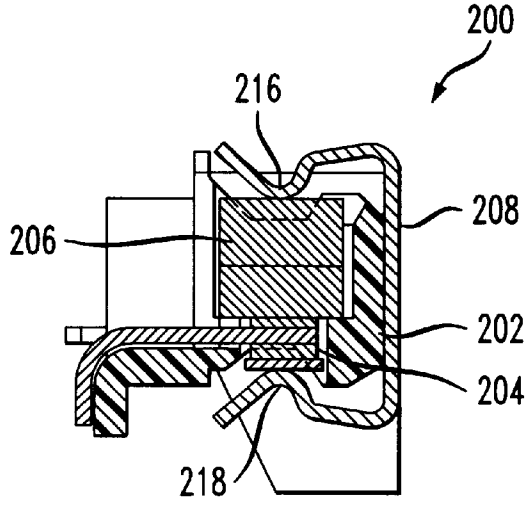
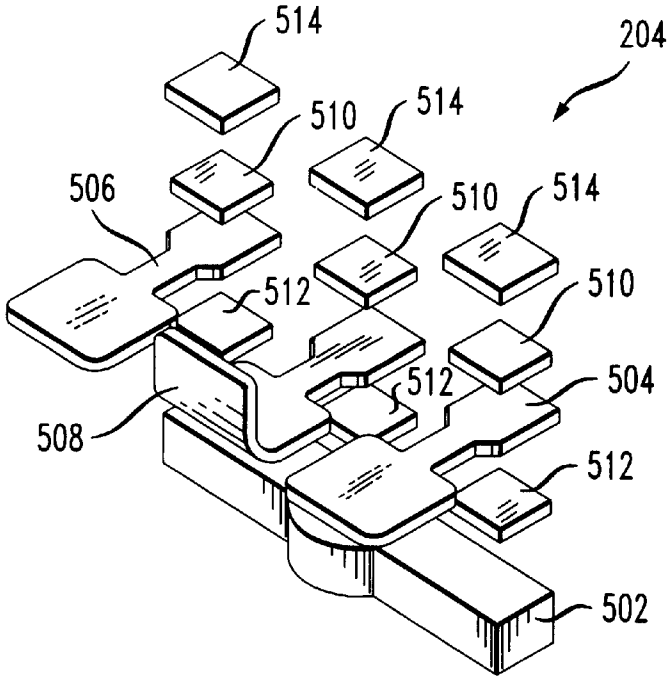


FIG. 5


514
204
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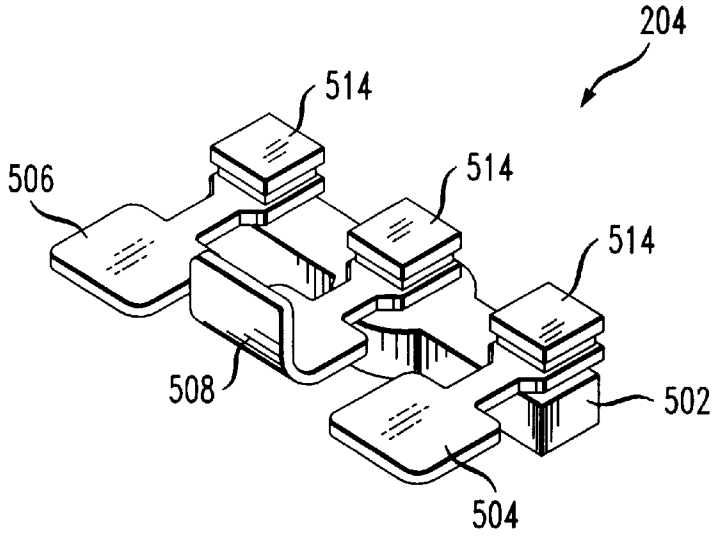
512
504
508
512
502

FIG. 6


204
514
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514
514
508
502
504

FIG. 7

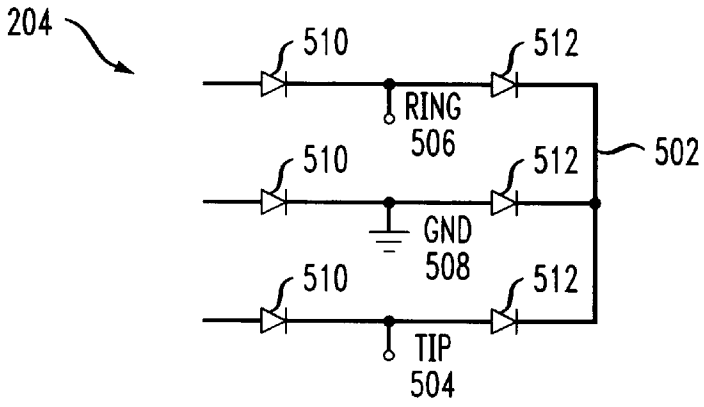
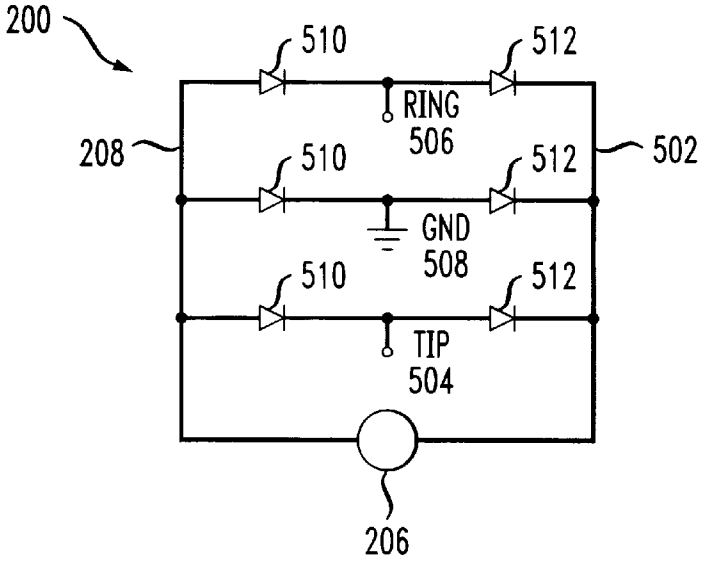

204
510
512
RING
506
502
510
512
GND
508
510
512
TIP
504

FIG. 8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RING
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208
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512
GND
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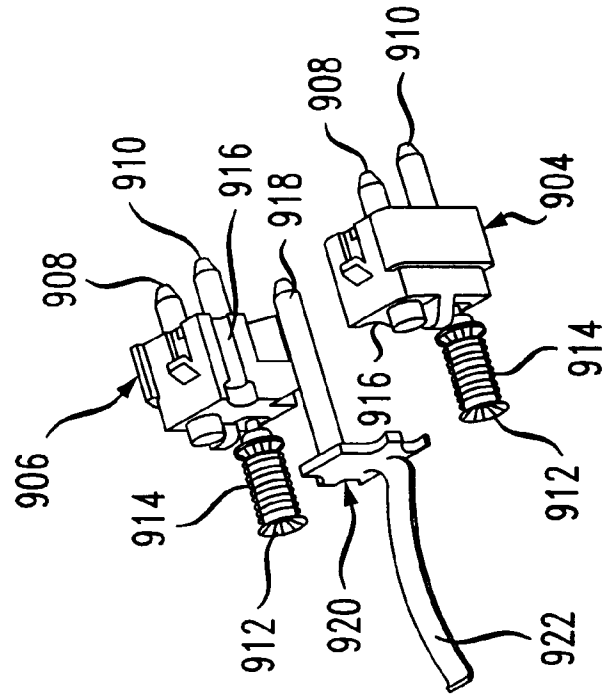
510
512
TIP
504
206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918
906
914
912
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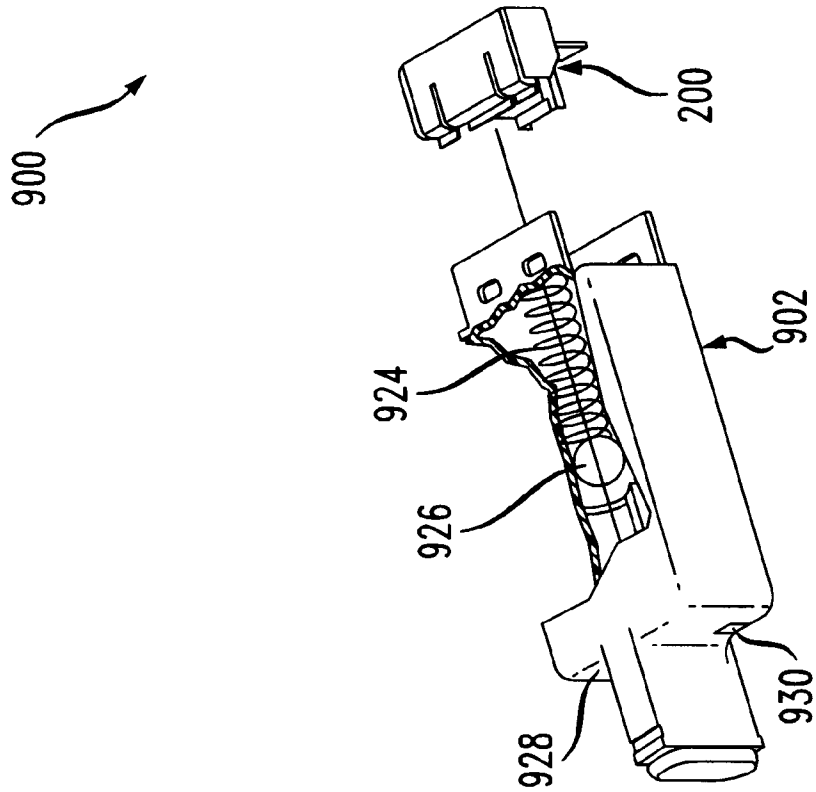
922
904


900
200
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924
926
928
930

FIG. 9

FIG. 10A

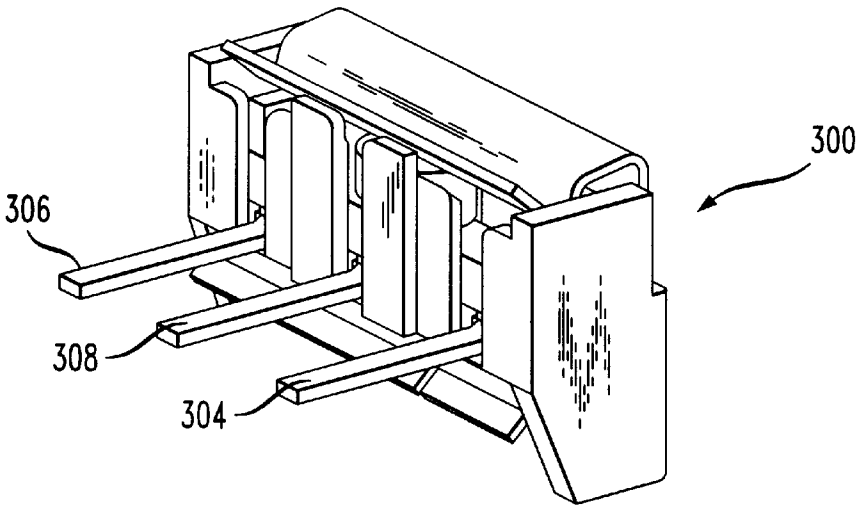


FIG. 10B

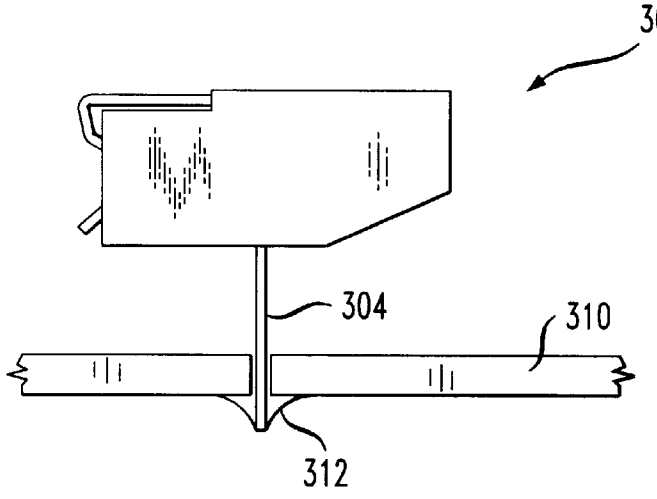


FIG. 11

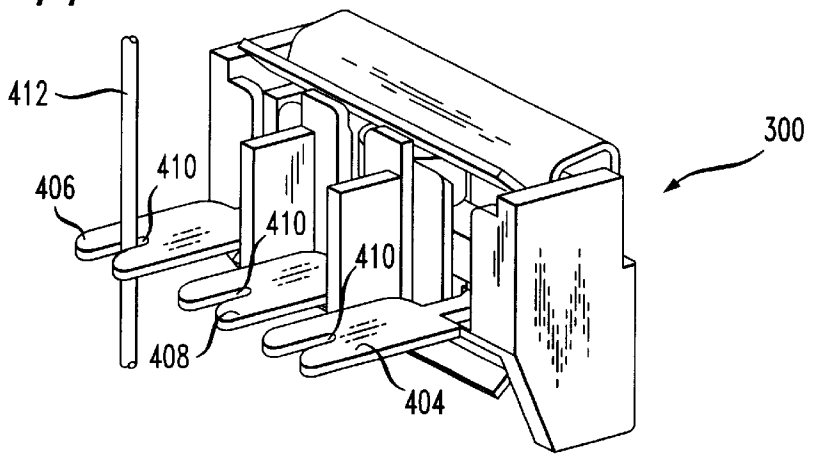


FIG. 12A

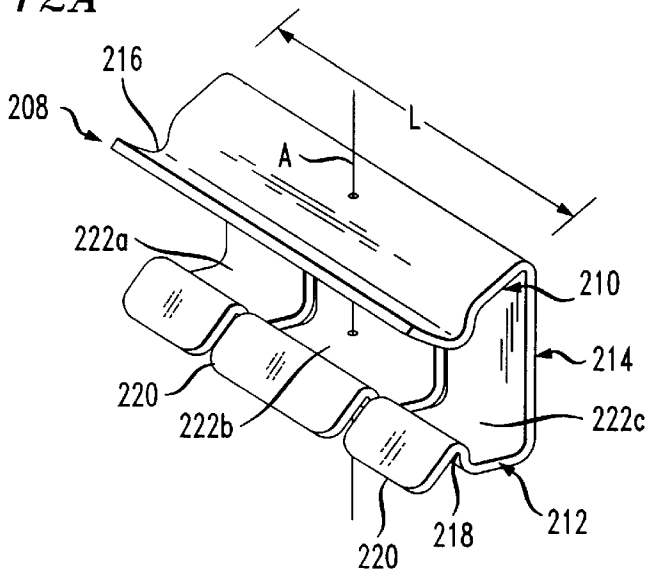


FIG. 12B

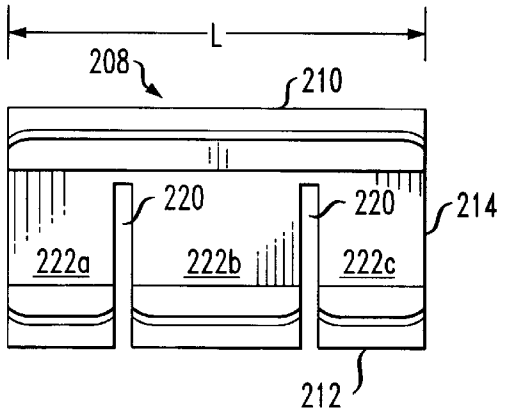


FIG. 13

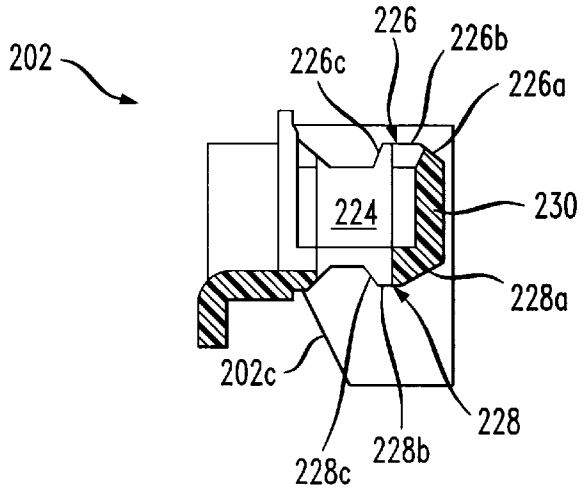
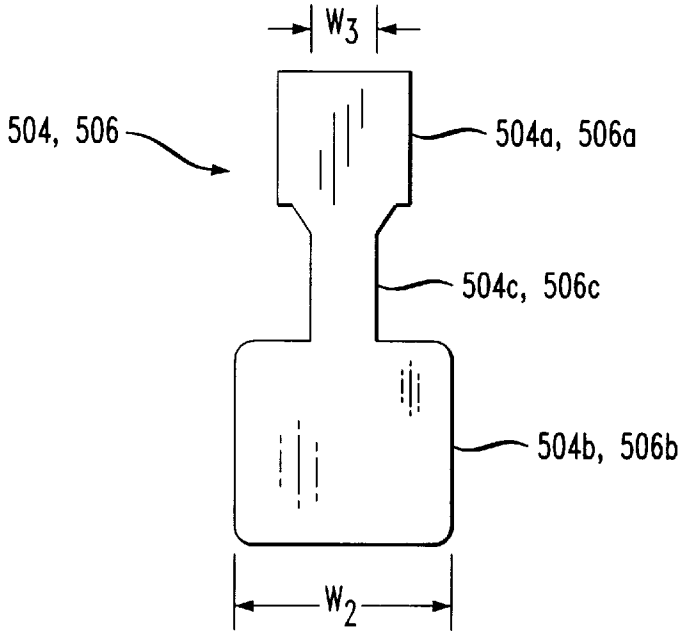

202
226
226b
226c
226a
224
230
228a
202c
228
228b
228c

FIG. 14


W3
504, 506
504a, 506a
504c, 506c
504b, 506b
W2

DIODE MODULE ASSEMBLY WITH BIFURCATED TERMINALS

RELATED APPLICATIONS

This application is related to co-pending U.S. application Ser. No. 09/096,688 filed Jun. 12, 1998, entitled VOLTAGE UNIT HOUSING; co-pending U.S. application Ser. No. 09/096,689 filed Jun. 12, 1998, entitled VOLTAGE UNIT BUS CLIP; and co-pending U.S. application Ser. No. 09/097,315 filed Jun. 12, 1998, entitled FLEXIBLE VOLTAGE UNIT TERMINAL.

FIELD OF THE INVENTION

This invention relates to the protection of communication equipment, and more particularly to improved arrangements for current and voltage overload protection.

BACKGROUND OF THE INVENTION

Protecting telecommunications equipment in telephone central offices or other locations against voltage surges and sneak currents is well known. For example, U.S. Pat. No. 4,796,150 discloses a solid state protector for insertion in a telephone line having tip and ring conductors. The protector comprises a current unit, a voltage unit and a pair of springs assembled within a housing structure. The voltage unit includes solid state devices that respond instantaneously to spurious voltage surges on the telephone line in the tip conductor, the ring conductor, or both tip and ring conductors. When a voltage surge exceeds a predetermined threshold, the voltage device operates to ground the telephone line thereby insuring that the spurious voltage bypasses the telephone equipment in the central office.

The voltage unit disclosed in U.S. Pat. No. 4,796,150 and similar voltage units including a voltage limiter, tip, ring and ground terminals and a plurality of diodes and metallic plates. All of these components are discrete elements which are not affixed to one another. These loose components must be assembled and maintained in a specific configuration within the voltage unit. If constant compressive force is not maintained in the assembly during manufacture of the voltage unit, the unit may fall apart and the small and fragile components may become lost or damaged, thereby requiring reassembly of the unit. With such reassembly comes attendant increases in manufacturing cost and time.

Additionally, by themselves, the voltage limiter, metallic plates, diodes and terminals possess utility separate and distinct from one another as a surge suppressor, simple conductor or diode, as the case may be. Individually, however, the several components cannot provide the sophisticated voltage surge protection of the voltage unit. Furthermore, their individual constructions are not adaptable, absent considerable modification, to other installation applications.

SUMMARY OF THE INVENTION

The present invention provides a voltage unit for use in a telecommunications protection unit having an electrically insulating housing configured to house a diode module assembly and a voltage limiting cell therein. The voltage limiting cell and the diode module assembly are retained within the housing by a bus clip.

To overcome the problem of loss or damage to individualized electrical components during assembly of a voltage unit and to broaden the installation capabilities of such components, the present invention provides an assembly

including a plurality of terminals and diode stacks integrated into a unitary, one piece module. The diode module assembly can be used by itself or with a voltage limiter to achieve a variety of desired electrical effects and can be installed in applications and environments including, but not limited to, a voltage unit, insulation displacement connections and wire wrapping. Constructed as a one-piece assembly, the module may be manufactured and stored in inventory. Thereafter, the module may be easily and reliably placed as a unit in, for example, a voltage unit housing without loss or damage to its constituent components.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1A** is an exploded, isometric view of an existing voltage unit adapted for use in a telecommunications protection unit;

FIG. **1B** is a plan view of the assembled voltage unit of FIG. **1A**;

FIG. **1C** is a partially cut side view of the assembled voltage unit of FIG. **1A**;

FIG. **1D** is a sectional view of the assembled voltage unit of FIG. **1A** taken along line D—D of FIG. **1C**;

FIG. **2** is an exploded, isometric view of an embodiment of a voltage unit in accordance with the present invention;

FIG. **3** is an isometric view of the assembled voltage unit depicted in FIG. **2**;

FIG. **4** is a sectional view of the assembled voltage unit depicted in FIG. **3**;

FIG. **5** is an exploded, isometric view of an embodiment of a diode module assembly in accordance with the present invention;

FIG. **6** is an isometric view of the assembled diode module assembly depicted in FIG. **5**;

FIG. **7** is an electrical schematic diagram of the assembled diode module assembly depicted in FIG. **6**;

FIG. **8** is an electrical schematic diagram of the assembled voltage unit depicted in FIG. **3**;

FIG. **9** is an exploded, isometric view of an embodiment of a telecommunications protection unit employing a voltage unit in accordance with the present invention;

FIG. **10A** is an isometric view of a further embodiment of an assembled voltage unit in accordance with the present invention;

FIG. **10B** is a view of the voltage unit depicted in FIG. **10A** fastened to a printed circuit board;

FIG. **11** is an isometric view of a further embodiment of an assembled voltage unit in accordance with the present invention;

FIG. **12A** is an isometric view of a preferred embodiment of a bus clip adapted for use with a voltage unit in accordance with the present invention;

FIG. **12B** is an elevation view of the bus clip depicted in FIG. **12A**;

FIG. **13** is an elevational cross-section view taken through a central region of a preferred embodiment of a voltage unit housing adapted for use with a voltage unit in accordance with the present invention; and

FIG. **14** is a plan view of a preferred embodiment of a contact adapted for use in a voltage unit in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Collectively referring to FIGS. **1A**, **1B**, **1C** and **1D**, there is shown a voltage unit manufactured by Lucent

Technologies, Inc., adapted for use in a telecommunications protection unit. The voltage unit, identified generally by reference numeral **100**, typically includes an electrically insulating base or housing **102** which may be formed from polybutylene terephthalate (PBT) or other suitable moldable material. Voltage unit **100** further currently includes a self-triggering surge suppressor (or surgistor or voltage limiter) **104** constructed as a cell or disc package. Voltage limiter **104** is preferably a unidirectional type P247 manufactured by Teccor Electronics. The voltage limiter **104** is sandwiched between two metallic plates **106** having outwardly extending elongate wing segments. Four diodes **108**, two on either side of the voltage limiter **104**, are sandwiched between the elongate wing segments of plates **106**. Diodes **108** are preferably PR4 type diodes manufactured by General Instrument. A metallic terminal **110** (either a tip or a ring terminal) is disposed between each of the two sets of diodes **108** and one of a pair of additional diodes **112**, which are preferably of the same or similar type as diodes **108**, is positioned exteriorly of a central region of each of the metallic plates **106**.

The operative electrical components of unit **100** are disposed within housing **102** in the manner most clearly depicted in FIGS. **1**B, **1**C and **1**D and are retained therein by a narrow (relative to the length of housing **102**) generally C-shaped metallic clip **114**. Clip **114** electrically contacts the diodes **112** and compressively maintains the unit **110** in assembled condition. Additionally, each of the terminals **110** of voltage unit **100** incorporates a notch **116** (FIG. **1**B) generally in a mid-region of each of its side edges to engagingly retain the terminals within the housing.

Although effective for its intended purpose, voltage unit **100** is costly to manufacture and rather difficult to assemble. Specifically, all of the electrical components of unit **100** are discrete elements which are not affixed to one another, yet must assume and maintain specific dispositions in the final assembly. If constant compressive force is not exerted against diodes **112** as clip **114** is placed thereon, or if clip **114** is improperly positioned on the diodes **112**, e.g., it pivots out of proper placement alignment, the unit **100** may literally fall apart during the manufacturing process. Hence, as many as thirteen parts may have to be recovered and realigned (both structurally and electrically) before the assembly may be reassembled. Further, because of their small size and delicate construction, one or more of the voltage limiters **104**, metallic plates **106**, paddle terminals **110** and/or diodes **108**, **112** may become lost or damaged if the assembly process fails. Moreover, even if assembly proceeds without apparent incident, the construction of housing **102** is such that it affords limited protection of the diodes **112** from crushing, chipping or similar damage which may occur as a result of the compressive and/or shear forces exerted by the clip **114** as it is positioned on diodes **112**. The clip **114** may also fail to retain the electrical components within the housing if one or more of the diodes **108**, **112** becomes damaged and reduces its thickness during operation.

The voltage limiter **104**, metallic plates **106**, diodes **108**, **112** and terminals **110** have utility separate and distinct from one another as a surge suppressor, simple conductor or diode, as the case may be. However, the cooperation of the several components to provide sophisticated voltage surge protection is possible only if clip **114** is present. Moreover, their individual constructions do not render either the diodes **108**, **112**, terminals **110** or clip **114** readily adaptable to other installation applications. For instance, unless considerably modified, the various electrical components of voltage unit **100** are incapable of attachment to a printed circuit board or individual wire conductors.

A typical telecommunications protection unit for which voltage unit **100** is adapted for use contains two heat coils for sneak current overload protection of the tip and ring circuits. One heat coil is in operative contact with the tip terminal of the pair of terminals **110** as well as a first office pin and a first line pin of the protection assembly. The other heat coil is in operative contact with the ring terminal of the pair of terminals **110** as well as a second office pin and second line pin of the protection assembly. The term "office" and words of similar import as used herein refer to components connected to the central office telecommunications equipment (e.g., switching, transmission equipment, telephone, modem or computer) whereas the term "line" and the like refer to the outside telecommunications lines which transport signals to and from the central office equipment.

Each of the terminals **110** make mechanical and electrical contact with a respective one of the heat coils. Either or both of the heat coils must move during a power surge or sneak current event. For the protection unit to function properly, each terminal **110** must also move and maintain electrical contact with its associated heat coil. Otherwise, protection is lost and the damaging power is transmitted to the office telecommunications equipment. The elongate wing segments of plates **106** impart a yieldable spring force against diodes **108** which permits limited motion of the terminals **110** and diodes **108**. To augment movement of the affected terminal(s) **110** during a power surge or a sneak current event, the side of each of terminals **110** opposite the heat coils is in contact with a compressed compression spring. The force exerted by the compression springs against the terminals **110** is intended to assure constant contact of either or both of terminals with the appropriate heat coil.

While generally useful to effectuate terminal movement under power surge or sneak current events, voltage unit **100** may be susceptible to failure in the event of exposure to certain voltage surges or sneak currents. That is, the limited movement afforded to the terminals **110** may be insufficient to provide rapid and reliable response to sudden movements of the heat coil(s) which might cause momentary breaches in contact between the affected terminal(s) **110** and the heat coil(s).

Referring to FIG. **2**, there is shown an exploded, isometric view of an embodiment of a voltage unit of the present invention, which finds beneficial use, inter alia, in a telecommunications protection unit, generally referred to as **200**. The voltage unit **200** includes an electrically insulating base or housing **202**. The housing is preferably molded using a polybutylene terephthalate (PBT) or other suitable material. Housing **202** includes a central region **202***a* bounded by a pair of end plates **202***b*, **202***c* and is configured with various receptacle areas and slots of suitable dimensions to house a diode module assembly **204** and a voltage limiter **206**. The voltage limiter **206** is preferably a type IEL limiter manufactured by Texas Instruments. An electrically conductive clip **208** described in greater detail with reference to FIGS. **12**A and **12**B retains the diode module assembly **204** and the voltage limiter **206** within the housing **202** as shown in FIGS. **3** and **4**. The material of the clip **208** is preferably a beryllium copper alloy. When assembled, as depicted in FIG. **3**, the voltage unit **200** establishes an electrical circuit as schematically depicted in FIG. **8** and results in a completed assembly consisting of four parts as opposed to the fourteen elements required to produce the voltage unit disclosed in U.S. Pat. No. 4,796,150.

An exploded, isometric view of the diode module assembly **204** is depicted in FIG. **5**. The diode module assembly **204** includes an electrically conductive bus bar **502**. The

material of the bus bar is preferably a copper alloy. A first terminal **504**, a second terminal **506** and a ground terminal **508** are each sandwiched between diodes **510** and **512**. Either first terminal **504** or second terminal **506** may serve as a ring terminal while the other may serve as a tip terminal. For purpose of illustration only, terminal **504** may be considered a tip terminal and terminal **506** may be considered a ring terminal. The diodes **510**, **512** are preferably type PR4 diodes manufactured by Texas Instruments and the material of the terminals **504**, **506** and **508** is preferably an annealed copper alloy. The diodes **510** are each sandwiched between a respective terminal **504**, **506** and **508**, and a terminal cap **514**. The material of the terminal caps **514** is preferably an annealed copper alloy. The bus bar **502**, terminals **504**, **506** and **508**, diodes **510** and **512** and terminal caps **514** are preferably soldered or otherwise electrically and mechanically affixed together to form the unitary assembled diode module **204** as shown in FIG. **6**. When assembled, the diode module establishes an electrical circuit as schematically depicted in FIG. **7**.

Among the advantages arising from the integral or unitary construction of the diode module assembly **204** of the present invention is that it simplifies assembly of the voltage unit **200**. For instance, the diode module assembly **204** is a single piece assemblage comprising several diode and conductor sub-components which can be easily and reliably placed as a unit in a correspondingly shaped receptacle in housing **202**. By contrast, the various diodes, terminals and plates of the voltage unit **100** shown in FIGS. **1A–1D** are "loose" items not integrally connected to one another. If not carefully placed individually into specific positions within housing **100**, and maintained in those positions under the influence of continuous compression until proper placement of clip **114**, one or more of these components may become misaligned or separated from the others. Consequently, the proper arrangement of parts must be carefully maintained before assembly of the voltage unit **100** may be completed. As will be appreciated, improper placement of any of the electrical components of voltage unit **100** requires reassembly of the unit and raises manufacturing costs.

The peripheral dimensions of bus bar **502**, terminals **504**, **506** and **508** and terminal caps **514** of diode module assembly **204** are desirably greater than the peripheral dimensions of diodes **510**, **512** with which they are in contact. With the diode module assembly **204** so constructed, the diodes **510**, **512** are effectively protected from physical trauma before, during and after placement of the diode module assembly into housing **202**.

Moreover, the modular nature of the diode module assembly **204** enables it to be manufactured and stored in inventory. Thereafter, it may be used, either by itself or as a component of a voltage unit (as will be described in greater detail and in connection with the discussion of FIGS. **10A**, **10B** and **11**), in an in-line telecommunications protection unit and other applications to produce electrical circuitry functions far more sophisticated, for example, than the individual diodes **108**, **112** of voltage unit **100**. Also, the diode module assembly **204** may be used with voltage limiters other than voltage limiter **206** to achieve differing levels of telecommunications equipment protection.

Referring to FIG. **9**, there is shown an exploded, isometric view of a telecommunications equipment protection unit, generally designated **900**, which employs a voltage unit **200** in accordance with the present invention. The protection unit **900** incorporates many of the structural features of the protection unit described in U.S. Pat. No. 4,796,150, the disclosure of which is incorporated herein by reference.

A presently preferred protection unit **900** includes a protector housing **902** formed from any suitable nonconductive material which may be molded and cured into a hollow, rugged and substantially rigid casing-type configuration. Protection unit **900** further includes a voltage unit, preferably unit **200** described above, a right coil assembly **904**, and a left coil assembly **906**. In a manner known in the art, each of the left and right coil assemblies **904**, **906** includes a housing formed from suitable nonconductive material which retains a central office pin **908** communicable with the telecommunications equipment to be protected and a line pin **910** communicable with the outside telecommunications lines which transport signals to and from the central office equipment. Rearward projections of each of the line pins **910** are mechanically soldered and electrically connected to metallic, e.g., copper, sleeves **912**. Surrounding each of the sleeves **912** is a heat coil **914**, one end of which is secured to the sleeve and the other end of which is secured to a rearward projection of an appropriate central office pin **908**. As is conventional, the heat coils **914** function as the sneak current limiters for protection unit **900**. The housings of each of the left and right coil assemblies **904**, **906** are preferably provided with a groove **916** adapted to accommodate approximately one-half of the circumference of a metallic ground pin **918** of a grounding assembly **920**. Grounding assembly **920** further includes a metallic leaf-type ground spring **922** integrally connected to ground pin **918** and adapted for abutting contact with the ground terminal **508** of voltage unit **200**.

Protection unit **900** additionally includes a pair of metallic compression springs **924**, only one of which is shown in FIG. **9**. A first end of each spring **924** contacts one of the tip and ring terminals **504**, **506** of voltage unit **200** and a second end receives a metallic ball-like cap **926** which normally abuts against the interior surface of a rear wall **928** of housing **902**. Rear wall **928** further preferably comprises a pair of openings **930** only one of which is shown in FIG. **9**. Each opening **930** is in alignment with a respective one of the caps **926** to permit testing for continuity of the line.

As known in the art, springs **924** exert compressive spring force against tip and ring terminals **504**, **506**. Springs **924** are provided to maintain contact between the tip and ring terminals and sleeves **912** during periods of normal operation and during voltage and/or current overload events. The operation of springs **924**, which itself does not form a part of the present invention, is described more fully hereinafter.

FIGS. **10A** and **10B** reveal a further embodiment of a voltage unit in accordance with the present invention. The voltage unit, identified generally by reference numeral **300**, is constructed and functions substantially similarly to previously described voltage unit **200**. Accordingly, only those elements of voltage unit **300** which materially differ from voltage unit **200** or are otherwise necessary for a proper understanding of the invention will be described in detail herein.

One difference between voltage unit **300** and voltage unit **200** lies in the construction of their terminals. For example, the tip and ring terminals **504**, **506** of voltage unit **200** lie in a common plane throughout their lengths (FIGS. **2–6**). Ground terminal **508**, however, lies in part in the plane established by tip and ring terminals **504**, **506** and in part deviates from that plane. Indeed, at its distal end, ground terminal **508** curves away from the common plane of tip and ring terminals **504**, **506** to an extent that it extends substantially perpendicular to such plane. It is this distal end of ground terminal **508** which abuts the ground spring **922** (FIG. **9**) when the protection unit **900** is in assembled condition.

In contrast, the three terminals of voltage unit **300**, respectively identified by reference numerals **304**, **306** and **308**, lie substantially in a common plane through their lengths. So constructed, terminals **304**, **306**, **308** may be inserted into appropriately sized and spaced slots or holes provided in a suitable substrate **310** such as a printed circuit board or the like and fixedly connected thereto by solder joints **312** or similar fastening means. It will also be understood that, although not illustrated, a diode module assembly similar to the diode module assembly **204** described hereinabove may also be affixed to a printed circuit board or similar substrate if provided with terminals constructed substantially similarly to terminals **304**, **306**, **308** of voltage unit **300**.

Referring to FIG. **11**, there is shown a further embodiment of voltage unit according to the present, identified generally by reference numeral **400**. Like voltage unit **300** discussed immediately hereinabove, voltage unit **400** is substantially similar to voltage unit **200** and only material differences therebetween will be emphasized herein. Additionally, like voltage unit **300**, a difference between voltage unit **400** and voltage unit **200** is in the construction of their terminals. More specifically, the terminals **404**, **406** and **408** of voltage unit **400** lie substantially in a common plane throughout their lengths and are bifurcated at their distal ends to form slots **410**. Slots **410** are desirably of suitable width to receive individual insulated wire conductors, one of which is represented by reference numeral **412**, and sever the insulation of such conductors so as to establish an insulation displacement connection (IDC) with such wires. And, although not illustrated, it will be appreciated that a diode module assembly similar to diode module assembly **204** may be affixed to wire conductors if provided with terminals constructed substantially similarly to terminals **404**, **406**, **408** of voltage unit **400**.

It will be understood that other diode module assemblies and/or voltage unit constructions consistent with the spirit of the present invention may be envisioned by those of ordinary skill in the subject art. For instance, the terminals of any of the diode module assemblies and/or voltage units of the present invention may be modified so as to accommodate wire wrapping or fitted with any suitable male or female connection elements so as to permit their connection to virtually any presently available circuitry, terminals or conductors.

FIGS. **12**A and **12**B respectively depict enlarged isometric and front views of a presently preferred embodiment of a bus clip **208** suitable for use in assembling any of the voltage units herein described. Clip **208** is substantially C-shaped in cross-section and has a length L spanning a majority or, more preferably, substantially the entire length of housing **202** between end plates **202***b*, **202***c* (FIG. **2**). A benefit arising from bus clip **208** extending for most and preferably nearly the entire distance between end plates **202***b*, **202***c* is that it is difficult to misalign the clip during placement. That is, end plates **202***b*, **202***c* function as lateral guides which effectively prevent undesirable rotation of the bus clip **208** about axis A (FIG. **12**A) during placement into housing **202**.

Clip **208** may be formed from any suitable metal stamping and/or bending techniques to produce a substantially stiff yet slightly yieldable member having flange portions **210**, **212** joined by a web portion **214**. Flange portions **210**, **212** preferably include contiguous longitudinal inward and outward bends which together define opposed inwardly protruding elongate contact ridges **216** and **218**. Upon assembly of voltage unit **200**, for example, contact ridges **216**, **218** compressively contact the outer surfaces of the voltage limiter **206** and diode module assembly **204**, respectively, to retain and electrically connect the several electrical components within the housing **202**.

A pair of spaced-apart, substantially parallel slots **220** extend generally transverse to the length L of clip **208** and preferably divide a substantial portion of web portion **214** and all of flange portion **212** into three independently yieldable segments **222***a*, **222***b* ad **222***c*. The contact ridge **218** of segment **222***a* is adapted to contact the diode stack, specifically, the terminal cap **514**, associated with terminal **506** (FIGS. **5** and **6**). Similarly, the contact ridge **218** of segment **222***b* is adapted to contact the diode stack (specifically, the terminal cap **514**) associated with terminal **508**, and the contact ridge **218** of segment **222***c* is adapted to contact the diode stack (specifically, the terminal cap **514**) associated with terminal **504**.

An advantage to segmentation of the bus clip **208** is that each segment **222***a*, **222***b*, **222***c* may operate independently to produce an essentially uniform contact force on each stack of diodes and provide reliable retention of the voltage unit assembly. Hence, if one stack of diodes becomes damaged and its thickness is reduced, the appropriate independently yieldable segment **222***a*, **222***b*, **222***c* moves accordingly to ensure contact with the damaged diode stack. Moreover, since each segment **222***a*, **222***b*, **222***c* independently moves to accommodate the height of its corresponding diode stack, precise manufacturing tolerances are not required for either the diode stacks or the bus clip **208** which reduces manufacturing costs and simplifies assembly of the voltage unit.

As mentioned previously, housing **202** of voltage unit **200** is formed with various receptacle and slot areas to accommodate the diode module assembly **204** and voltage limiter **206**. One of those areas, identified by reference numeral **224** is shown in FIG. **13**. Area **224** is of sufficient size to receive both the diode module assembly **204** and voltage limiter **206** in the manner shown in FIG. **4**. In existing voltage unit designs such as, for example, voltage unit **100** (FIGS. **1**A–**1**D), the exposed edges of diodes **112** may experience crushing, chipping and related damage as a result of the compressive and/or shear forces exerted by the clip **114** during assembly of the voltage unit. Such trauma may require replacement of one or more of the diodes thereby increasing manufacturing time and cost.

Housing **202** is desirably constructed to overcome this problem. More particularly, housing **202** is desirably configured with structure for preventing direct contact of the contact ridges **216**, **218** of bus clip **208** with anything other than the exposed oppositely facing surfaces of the voltage limiter **206** and the diode stacks (specifically the terminal caps **514** shown in FIGS. **5** and **6**).

As seen in FIG. **13**, a presently preferred structure for protecting the diode module assembly **204** and voltage limiter **206** from damage during placement of bus clip **208** is at least one, or more preferably, a pair of guide members **226** and **228** provided along first and second opposite edges of a longitudinal housing wall **230** connecting and extending substantially perpendicular to end plates **202***b*, **202***c*. Guide members **226**, **228** each preferably include an outwardly inclined first portion **226***a* and **228***a*, respectively. The first portions **226***a*, **228***a* urge outward separation of the contact ridges **216**, **218** of the first and second flange portions **210**,**212** of the bus clip **208** with respect to the housing **202** as the clip is moved onto the housing (i.e., as the clip is moved from right to left with respect to housing when the

housing is disposed in the orientation shown in FIG. **13**). Adjacent and preferably contiguous with outwardly inclined first portions **226***a*, **228***a*, guide members **226**, **228** further preferably include substantially uninclined second portions **226***b* and **228***b*, respectively, for maintaining the first and second webs **210**, **212** in an outwardly urged or expanded condition and out of contact with the exposed comers and outwardly facing surfaces of the voltage limiter **206** and voltage diode assembly **204** as the bus continues leftwardly with respect to the housing **202** in FIG. **13**.

Optionally, guide members **226**, **228** further comprise inwardly inclined third portions **226***c* and **228***c*, respectively. Third portions **226***c*, **228***c* are disposed adjacent and preferably contiguous with the second portions **226***b*, **228***b* and permit somewhat controlled inward movement or contraction of the first and second flange portions **210**, **212** with respect to the housing **202** as the bus clip continues leftward onto the housing. Upon passing the guide members **226**, **228** the contact ridges **216**, **218** of bus clip **208** come to rest directly upon the oppositely directed faces of the voltage limiter **206** and the diode stacks, specifically, the terminal caps **514**, of the diode module assembly **204** as reflected in FIG. **4**. As such, The fragile edges of the voltage limiter **206** and diode module assembly **204** are protected from harm from the bus clip **208** during assembly.

FIG. **14** illustrates a presently preferred construction of the terminals **504**, **506**, **508** described above in connection with FIGS. **5** and **6**. As mentioned previously, it is known to use compression springs in telecommunications protection units such as unit **900** (FIG. **9**) to enhance contact between the terminals of the voltage unit and the protection unit's heat coil sleeves. Under the influence of an excessive power surge or sneak current, the affected heat coil(s) heat up and the solder which connects a particular heat coil to its associated line pin melts. The sleeve about which the heat coil is wrapped is then urged to slide toward under the influence of the compression spring and contact the grounding assembly, thereby diverting the damaging voltage and/or current to ground.

As the sleeve slides, it carries its associated heat coil. If the tip and/or ring terminal of the voltage unit loses contact with the moving sleeve, the damaging power is sent to the telecommunications equipment rather than to ground. The paddle or terminal portions of contacts **110** (FIGS. **1**A and **1**B), for example, are designed for limited movement under the influence of a compression spring such as spring **924** (FIG. **9**) upon the occurrence of a voltage surge or sneak current event. However, some sudden movements of sleeves **912** may be of sufficient magnitude to breach contact of the terminals **110** with the sleeves **912**.

Terminal movement responsiveness may be enhanced by substituting the compression springs **924** with heavier duty springs with higher spring force. However, the force associated with such springs may damage other components of protection unit **900**. Rather than using more forceful springs, the present invention proposes increasing the flexibility of the tip and ring terminals **504**, **506**.

Tip and ring terminals **504**, **506** are preferably formed from copper alloy approximately 0.016 inch in thickness. As illustrated in FIG. **14**, each terminal **504**, **506** is preferably comprised of three portions. The first portion **504***a*, **506***a* is disposed between diodes **510** and **512** (FIG. **6**). The second portion **504***b*, **506***b* is generally paddle-shaped and contacts the end of the compression spring **924** and the sleeve **912** as shown in FIG. **9**. A comparatively narrow third portion **504***c*, **506***c* connects the first and second portions.

When the width W_3 of the terminal third portion **504***c*, **506***c* is about 50% or less of the width W_2 of the second portion **504***b*, **506***b*, increases in terminal flexibility are realized versus terminals configured according to terminals **110** of voltage unit **100**. Moreover, the considerable flexibility imparted to terminals **504**, **506** by third portions **504***c*, **506***c* reduces potential stresses from harming the integrity of the diode stack assemblies.

According to a presently preferred embodiment, for example, the width W_2 of second portion **504***b*, **506***b* is preferably about 0.14 inches and the width W_3 of the third portion **504***c*, **506***c* is approximately 0.04 inches. W_3 is thus approximately 29% of W_2. In contrast, the width of the corresponding notched portion of terminals **110** of voltage unit **100** is approximately two-thirds of the width of the paddle-shaped contact portion. Such a reduction in the terminal width of terminals **504**, **506**, however, has been found to afford sufficient strength to withstand the rigors normally encountered in the operation of a telecommunications protection unit yet provide terminal flexibility sufficient to respond to sudden movements of sleeve **912** (FIG. **9**).

We claim:

1. A diode module assembly comprising:

a plurality of bifurcated terminals;

a plurality of diode stacks affixed and electrically connected to said plurality of terminals wherein each one of said diode stacks is associated with a respective one of said terminals; and

a bus bar affixed and electrically connected to said diode stacks.

2. The diode module assembly as defined in claim **1** wherein said plurality of terminals comprise a tip terminal, a ring terminal and a ground terminal.

3. The diode module assembly as defined in claim **2** wherein at least said tip and said ring terminals lie in a substantially common plane throughout their lengths.

4. The diode module assembly as defined in claim **3** wherein said ground terminal lies in part in said plane and in part deviates from said plane.

5. The diode module assembly as defined in claim **1** wherein each of said diode stacks comprises a diode disposed on opposite sides of a respective one of said terminals.

6. The diode module as defined in claim **5** wherein each of said diode stacks further comprise a terminal cap disposed on a side of said diode stacks opposite said bus bar.

7. An assembly comprising:

a voltage unit having a diode module assembly comprising:

a plurality of bifurcated terminals;

a plurality of diode stacks affixed and electrically connected to said plurality of terminals, wherein each one of said diode stacks is associated with a respective one of said terminals; and

a bus bar affixed and electrically connected to said diode stacks; and

a plurality of wires electrically connected to the terminals.

8. An assembly according to claim **7**, wherein the terminals are insulation displacement connection terminals.

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